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STUDIES ON MYRMECOPHILES. I. CREMASTOCHILUS.

By WILLIAM MORTON WHEELER,
NEW YORK CITY.

The phlegmatic beetles of the exclusively North American genus *Cremastochilus* have been extensively collected by coleopterists, but very little study has been devoted to their habits. And though all collectors know that these beetles, of which some twenty-five species have been described, are regular myrmecophiles, it is a rare experience to find one of them mounted with its host ant in a collection. Indeed, with the exception of a few data published several years ago (1890) by one of our eminent coleopterists, Dr. A. E. Schwarz, I can find no records of the species of ants among which the *Cremastochili* pass so much of their lives. I therefore publish the following observations in the hope that they may induce some of our entomologists to make accurate notes of their future captures of these extraordinary insects.

Mr. L. H. Joutel having kindly identified the *Cremastochili* in my collection, I am able to present the following records of fourteen species, including those mentioned by Schwarz:

1. *Cremastochilus spinifer* Horn. — A single specimen taken June 6, 1902, from a nest of *Pheidole desertorum* Wheeler under a stone in the desert near Fort Davis, Texas.

2. *C. wheeleri* Lec. — Taken repeatedly during July and August, 1903, and 1906 at Colorado Springs, Manitou and Boulder, Colo., in the nests of *Formica oreas* Wheeler, *crinita* Wheeler, *microgyna* Wheeler and its variety *rasilis* Wheeler, *ciliata* Mayr, and *rufa* L. subsp. *obscuripes* Forel.

3. *C. crinitus* Lec. — Taken repeatedly during May, 1903, by Messrs. C. T. Brues, A. L. Melander and myself near Austin, Texas, in the nests of *Formica fusca* L. var. *gnava* Buckley.

4. *C. retractus* Lec. — Also taken at Austin in nests of *F. gnava*, but much less frequently than *C. crinitus*. I have also taken it (July 19, 1903) in nests of *F. ciliata* at Colorado Springs.

5. *C. harrisi* Kirby. — Mr. Wm. Beutenmüller has given me a few specimens of this beetle which he took in the Black Mts. of North Carolina in nests of *Formica pallidefulva* Latr. subsp. *schaufussi* Mayr. I have also found it as late as September 16, at Lakehurst, N. J., in a

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colony of *F. sanguinea* L. subsp. *rubicunda* Emery var. *subintegra* Emery, with *F. schaufussi* as slaves.

6. *C. canaliculatus* Kirby. — Taken in the following localities and with the following ants: Newfoundland, N. J. (April 27, 1907), with *F. schaufussi*, and *rubicunda*, with *fusca* L. var. *subsericea* Say as slaves (Davis and Wheeler); Westfield, N. J. (May 18), with *F. exsectoides* Forel (Davis); Andover, Mass., with *F. subsericea* (A. P. Morse).

FIG. 1. *Cremastochilus castaneæ* Knoch. ×4.

7. *C. castaneæ* Knoch (Fig. 1). — Occurring, like the preceding, with a number of species of *Formica:* Black Mts., N. C., with *F. subsericea* (W. Beutenmüller); Newfoundland, N. J. (April 27, 1907), with *F. schaufussi* and *exsectoides* (Davis and Wheeler); Washington, D. C., with *F. rufa* subsp. *integra* Nyl. (Schwarz); same locality with *F. schaufussi* (Pergande); Bronxville, N. Y. (April 19, 1904; April 19, 1908), with *F. schaufussi* and with *Polyergus rufescens* Latr. subsp. *lucidus* Mayr with *F. nitidiventris* Emery as slaves (Wheeler); Greenville, N. Y. (July 30, 1904), with *F. subsericea* (Wheeler); Westfield, N. J. (May 18), with *F. exsectoides* (Davis); Cañon City, Colo. (March 23), with *F. fusca* var. *argentata* Wheeler (Rev. J. Schmitt).

8. *C. mexicanus* Schaum. — Taken by Mr. C. Schaeffer in the Huachuca Mts. of Arizona, in a nest of *F. gnava*, and by Mr. H. A. Wenzel in the same locality in nests of *F. rufa obscuripes* var. *rubiginosa* Emery.

9. *C. variolosus* Kirby. — Recorded by Schwarz as occurring in nests of *Stenamma* (*Aphænogaster*) *fulvum* Roger.

10. *C. squamulosus* Lec. — This species, which occurs in Georgia and Florida, is cited by Schwarz as living with *Camponotus esuriens*, an ant which does not occur in the United States. What has been passing under this name is in all probability *C. abdominalis* Fabr. var. *floridanus* Buckley or one of the southern forms of *C. maculatus* Fabr.

11. *C. planatus* Lec. — This and the two following species were taken during July and August by Mr. H. A. Wenzel in Miller Cañon, Huachuca Mts., Ariz. (5,000 to 6,000 ft.) in nests of *F. rubiginosa*.

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12. *C. planipes* Horn.

13. *C. opaculus* Horn.

14. *C. ineptus* Horn. — Mr. H. W. Wenzel informs me that this species was taken in the same locality as the three preceding species and with the same ant by Mr. H. Kaeber.

These records show that in the great majority of cases the hosts of *Cremastochilus* belong to the genus *Formica*. Although *C. spinifer* has been taken with *Pheidole*, *C. variolosus* with *Aphænogaster* and *C. squamulosus* with a species of *Camponotus*, it is practically certain that these are accidental or irregular associations. Hence we should expect the beetles to be found only within the geographical range of the genus *Formica*, and this appears to be the case. Even the four species cited in the "Biologia Centrali-Americana" (*C. saucius*, *planatus*, *mexicanus* and *crinitus*) occur within the United States, and have been taken in Mexico only on the high northern plateau where *Formica* also occurs. It is not improbable that some or all species of *Cremastochilus* prefer to live with particular species of *Formica*, but this cannot be proved without a great many more records than I have been able to obtain heretofore.

Haldeman (1848) seems to have been the first to publish an account of the occurrence of *Cremastochilus* in ant-nests, but the correspondence of Hentz, Say and Harris published by Scudder in 1869, shows that as early as 1825 Hentz had seen ants dragging a specimen of the beetle over the ground. Horn (1871) says that he found *C. schaumi* and *angularis* "very frequently in ants'-nests and in one instance apparently eating the pupæ. Several times I have seen large black ants dragging specimens of *schaumi* along the surface of the ground towards their nests and on examination have frequently succeeded in obtaining from nests specimens that had previously been dragged there. Why these insects are found with ants is a question to which I am not prepared to give a definite answer, unless, as I suspect, the fossæ at the anterior angles and the finely punctured and apparently perforated patches under the hind angles are glandular and yield some secretion grateful to the ants." The patches to which Horn alludes are tufts of golden yellow or orange-red hairs, the trichomes, which characterize so many myrmecophilous insects, and are most beautifully shown on various parts of the body in beetles of the genera *Adranes*, *Claviger*, *Paussus*, *Lomechusa*, *Xenodusa*, etc.

In 1886 Horn published some additional notes on the habits of

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Cremastochilus. He received from J. J. Rivers, of California, a specimen of *C. schaumi* with the posterior thoracic angles mutilated, and from J. Hamilton, of Allegheny, Pa., one of *C. canaliculatus* in a similar condition. Concerning these specimens he writes as follows: "It is my belief that the irregularities in the Rivers and Hamilton specimens are the work of the ants, with which the specimens were found and I have long held the opinion and have so published it, that the pubescent depressed spaces near the front and under the hind angles of most of the species, are glandular, and give a secretion very palatable to the ants, and these almost reasoning insects, finding the processes in their way have deliberately removed them, either partially, as in the Rivers specimen, or entirely as in the other." Horn also quotes from Schwarz the following interesting observation on a species of *Cremastochilus* which was apparently living with *Formica exsectoides*: "In May, 1883, while on an excursion in the vicinity of Washington, I came across a large ant hill constructed by a species of *Formica* which is allied to, but not identical with, *F. rufa*. My attention was at once attracted by three objects on top of the ant hill, which at first glance appeared to be compact masses of ants. Upon looking closer to each of the masses proved to consist of a living *Cremastochilus* attended by numerous ants which held on with their mandibles to the legs, the head, the sides of the thorax of the beetles, in short wherever there was a chance for them to hold on. That they did not intend to do any harm to the beetles was evident, and it seemed to me that they intended to prevent the escape of the *Cremastochili* from their colony. Herein they were evidently successful, as upon waiting for a considerable length of time there was no change in the situation. I then proceeded to investigate the interior of the ant hill, which consisted of numerous layers of intricate galleries and chambers, all built of rather loose earth without any sticks or other debris. Within the chambers several more *Cremastochili* were found but not attended to by ants."

Hamilton (1888–1889), in his excellent list of myrmecophilous insects, cites a number of species of *Cremastochilus* but without the names of their hosts. Of *C. canaliculatus* he says, that it is the most abundant species at Allegheny, Pa. "It is found from April till June with large black ants, perhaps of two species, inhabiting usually under stones or other covering, but not infrequently throwing up small mounds in old pastures and open ground. The nests under

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stones rarely yield more than two beetles, but the mounds often contain five or six at once, and with care will yield a crop every two or three weeks. The beetles are found near the surface, none having been taken below the plane of the base. As soon as it becomes warm, from the middle of April onward, this species takes leave of the ants and flies away; like the Cicindelæ it only flies during the hottest sunshine and for short distances, alighting suddenly on a stone or the middle of a dusty road. Its flight is low and heavy, and after it lights cannot take wing again without some delay, and I have seen it flying as late as August. Whether after having left, the same beetles return and breed among the ants, or whether it is a new brood that claims their hospitality for the winter, is absolutely unknown. I never could satisfy myself as to whether those found in the nests in June had returned or were just preparing to leave."

In 1891 Lugger published a few observations on *C. knochi* Lec. which he found at St. Anthony Park, Minnesota. He saw the beetles mating during the early spring in an open field and being dragged about by ants (species not mentioned). One individual "was found sitting right over one of the small entrances of an ant nest. With slow and very deliberate actions the beetle gradually enlarged the hole under it, and in the course of nearly seven hours disappeared from view." Lugger figures a peculiar cavity which was excavated in the earth by five pairs of *C. knochi* kept in a jar.

The observations above cited are all or nearly all that have been published on the habits of *Cremastochilus*. In order to ascertain the relations of these beetles to the ants I have on several occasions installed specimens of *C. crinitus* in artificial nests with *F. gnava* and of *C. canaliculatus* and *castaneæ* with *F. subsericea*, *schaufussi*, *nitidiventris* and *integra*. Beetles kept with the colonies in which they are first taken, are treated with complete indifference by the ants. This is sometimes the case also when the beetles are placed in a strange colony of the same species of *Formica*, especially if this is *F. schaufussi*. More frequently a different picture, like that seen in the following experiment, is exhibited: April 19 I placed two *C. castaneæ*, that had passed the winter with *F. schaufussi*, in a Fielde nest containing several hundred workers and two deälated queens of *F. integra*. The beetles at once "feigned death" and remained for several minutes lying on their backs, with retracted legs and antennæ. They were not noticed till they stretched out their appendages and began to walk

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about. Then the ants at once pounced upon them with open mandibles and curved their gasters forward between their hind legs, in the attitude assumed by all the forms of *F. rufa* when irritated and about to discharge their formic acid. There could be no doubt that the ants were hostile and irritated but nevertheless the acid batteries were never called into action, probably because there is a disinclination to use these organs within the narrow confines of the nest. They contented themselves with biting the beetles and pulling their legs. It soon became apparent, however, that the biting was largely restricted to the posterior corners of the beetle's thorax. The ant clung to the side of the beetle in the position shown in Fig. 2, seized the posterior angle between its mandibles in such a manner that the toothed border of one mandible fitted into the arcuate groove which separates the angle from the more convex portion of the thorax, and then moved its head from side to side in a vigorous attempt to tear away the triangular piece of chitin bearing the cushion of trichomes on its ventral surface. Several of the workers busied themselves thus for periods varying from one to twenty minutes, and one pertinacious individual gnawed at the posterior thoracic angle of the same beetle for an hour and a quarter. The anterior angles and the legs were also gnawed and pulled, but much less frequently and persistently. With a pocket lens it was possible to study the mouth-parts of the gnawing ant. There was no attempt to lick any portion of the beetle's body. In fact, the ant, while gripping the thoracic angle, kept its mouth tightly closed and held its maxillary palpi back against the gula while the labial palpi, with a rhythmic movement approached, but did not actually touch, the trichomes. The gnawing seemed to irritate or, at any rate, to stimulate the beetle, for it stalked rapidly about the nest carrying the ant on its back. Whenever the anterior part of its body was touched by an ant, it quickly retracted its antennæ, so that it could never be seized by these appendages. Eventually it managed to force its head and thorax into a corner or under the wet sponge.

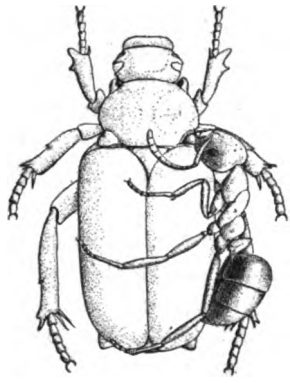

FIG. 2. *Cremastochilus castaneæ* with *Formica integra* worker gnawing at one of its posterior thoracic angles. ×4.

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Then the ant had to release its hold. Sometimes it continued to gnaw at the exposed abdomen, elytra or legs, but sooner or later it left the beetle to its own devices. The creature then remained for hours in somnolent quiescence till some enterprising ant would pull it out of its ostrich-like concealment by one of its hind legs and the gnawing at the posterior thoracic angles and the march of the beetle around the nest would recommence.

The beetles were observed daily for several weeks. At times I was inclined to believe that the ants had grown accustomed to their presence and were beginning to tolerate them with indifference, but closer observation showed that whenever the beetles left their retreat and wandered about the nest they were sure to be assaulted by a few of the ants and to have their thoracic angles gnawed till they again succeeded in concealing themselves. This behavior on the part of the ants continued without modification till June 10 and 13, when the two beetles died and were placed on the refuse heap by the *integra* workers.

A specimen of *C. castaneæ* was also placed in a nest of *F. subsericea*. Though this ant has a much more cowardly disposition than *F. integra*, it nevertheless attacked the beetle as soon as it spread its legs and proceeded to move about the nest. There was the same gnawing at the posterior thoracic angles as exhibited by *integra*, but more pulling at the beetle's legs. The *subsericea* workers treated the beetle much as they treat an alien queen: each seized a leg and then, fixing its claws in the towelling or sponge of the nest, began to pull. As the mandibles of *subsericea* are weaker than those of *integra*, there was even less danger of injury to the beetle, which dragged the ant along till it found a corner in which it could bury its head and thorax and enjoy a spell of immunity from their attacks.

The imaginal *Cremastochili* seem to require no food. At any rate, I have never seen them eating any substances in the nests or being fed by the ants, although I have kept them under observation from three to seven weeks. Some of the nests in which they were confined contained ants' eggs and young larvæ, but these were completely ignored by the beetles. In the natural nests the latter are sometimes present in much greater numbers than is suggested by Hamilton's statement above quoted. April 27, 1907, at Newfoundland, N. J., Mr. Wm. T. Davis and I took from a single nest of *F. schaufussi* 24 *Cremastochili*, belonging to two species, *castaneæ* and *canaliculatus*.

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This is the more surprising because the colonies of *schaufussi* are very small compared with those of *subsericea*, *integra*, *exsectoides*, etc.*

From the foregoing observations we may conclude that the *Cremastochili* are not true guests, or symphiles, as Wasmann supposed (1894), but persecuted intruders (synechthrans) that may eventually become indifferently tolerated guests (synœketes). This explains the observations of previous writers. The three *Cremastochili* which Schwarz found arrested by the *F. exsectoides* workers were, in all probability, individuals that had only just alighted on the mound, whereas those taken in the galleries of the nest were old inhabitants. The specimens with defective thoracic angles, described by Horn, had probably been mutilated by the ants, as he suggests. Such mutilations, however, would hardly be possible except in individuals that had just escaped from their pupa-cases and were still soft. The view here advocated is supported by the remarkable development of the protective devises of the *Cremastochili:* their hard armor, the extraordinary cup-shaped mentum which prevents the ants from getting at the mouth-parts and the facility with which they can withdraw their antennæ into deep grooves on the sides of the head.

But if this view is accepted, how are we to interpret the tufts of yellow hairs, or trichomes on the thoracic angles, their obvious fascination for the ants and the peculiar oily red "myrmecophile color" of some of the species (*C. saucius* and *spinifer*)? That the thoracic angles represent adaptations to myrmecophily can hardly be doubted. I have called attention to the remarkable manner in which these structures, at least in some of the species, fit the mandibles of the *Formica* workers. As the glands on these angles unquestionably emit some odor which simultaneously attracts and irritates the ants, one would be inclined to account for their development by supposing that they tend to withdraw the hostile attentions of these insects from more vulnerable organs.† But what are these organs? All parts of the

* Mr. Davis calls my attention to the fact that Hamilton's statements in regard to the flight of *Cremastochilus* are not strictly applicable to all the species. A considerable number of *C. harrisi* were seen by Mr. Davis during the past April flying along the roads in the sandy pine barrens at Lakehurst, N. J. They were very agile and difficult to catch, taking flight again after alighting with as much ease as *Cincindelæ*.

† It is interesting to note that the European and North American species of an allied genus of Cetoniine beetles, *Osmoderma* (*O. eremita* L., *eremicola* Knoch and *scabra* Beauv.), have long been noted for their peculiar odors. Concerning our

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beetles' surface are thoroughly indurated and equally adapted to repelling the mandibular onslaught. There seems to be only one way out of the difficulty thus presented by the simultaneous development of these protective and alluring adaptations in the *Cremastochili*, and that is to regard these beetles as degenerate symphiles, forms that were once true guests, with more highly developed trichomes and living on much more amicable terms with their hosts. In having fallen from this estate they resemble certain species of *Paussus* that have been studied by Escherich. *Cremastochilus* has, in fact, all the ear-marks of a very senile genus. Its species, like somber hypochondriacs, are condemned by an ancient instinct to dwell in the busy emmet world without participating in its splendid activities. The weariness of a long and eventful evolution seems to lurk in their hard, pock-marked integument and rheumatic joints. Having outlived a period of abject sycophancy, they would, perhaps, return to a free and independent life, were it not that their brains have been enfeebled by too many generations of parasitism.

Nothing is known concerning the development of *Cremastochilus*. The larval and pupal stages are passed, in all probability, in the ant-nests, and from what has been learned of allied forms, like *Cetonia*, we should expect to find the larva in the vegetable débris of the nest. July 22, 1903, while examining a nest of *Formica microgyna* in Williams Cañon near Manitou, Colorado, I found besides a number of adult *C. wheeleri*, a single Cetoniine larva, which may be that of this beetle. It was buried in the vegetable débris and on being exposed by a stroke of my trowel, was at once seized and injured by the irate ants. It resembles rather closely the larva of *Osmoderma eremita* figured by Schiödte (De Metamorphosi Eleutheratorum Observationes, VIII, 1874, Tab. XI, Fig. 1). If it is the larva of *C. wheeleri* it is only about two thirds grown.

The mating of *Cremastochilus* sometimes takes place in the ant-nests. At any rate I have seen pairs of *C. castaneæ* and *canaliculatus in copulâ* in the outer galleries of *F. schaufussi* nests in April. Liebeck (1899) took the mating sexes of *C. leucostictus* Burm., which are

American species Harris (A Treatise on Some of the Insects Injurious to Vegetation, 1862, p. 42) says: "They have the odor of Russian leather, and give this out so powerfully that their presence can be detected by the scent alone, at the distance of two or three yards from the place of their retreat." This scent is retained for years in cabinet specimens.

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very dissimilar, in the open field, and it is probable that this is the more usual mating place. The beetles undoubtedly spend much of their adult life with the ants. They certainly hibernate in the nests as they were found both by Hamilton and myself in the early spring (middle of April) in the upper galleries. Moreover, the dates above mentioned (p. 68) show that they may be found in the nests as late as July, August and September. It is probable, therefore, that the eggs are laid in May and that the adult beetles make their appearance towards the middle or latter part of the summer and then remain with their hosts till the following spring.

The genus *Cremastochilus* belongs to the Cetoniine subfamily of the Scarabæidæ and has its closest allies, curiously enough, in certain South African genera. These are in part myrmecophilous and in part termitophilous. To the former group belong *Plagiochilus intrusus* Wasmann (1900), *P. argenteus* Wasm. and *Myrmecochilus marshalli* Wasm. (Fig. 3), both occurring in the nests of a very common South African ant, *Plagiolepis custodiens*. To the latter group belong five species of *Cœnochilus* (*termiticola* Wasm., *braunsi* Wasm., *glabratus* Boh., *hospes* Péringuey and *intrusus* Pér.). In this same region there are also a number of other myrmecophilous and termitophilous Cetoniinæ not so closely allied to *Cremastochilus*. Péringuey (1900) mentions *Placodidus compransor* and *Trichoplus schaumi* as occurring in the nests of *Plagiolepis*, and species of *Scaptobius* and *Lissogenius* as myrmecophiles. The same author surmises that *Trichostetha capensis* is termitophilous, and one who has seen this remarkable green and black beetle, which measures nearly 3½ cm. in length and has its ventral surface covered with great tufts of orange-red hairs, can hardly doubt that it lives with ants or termites.

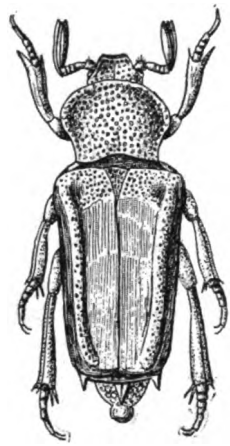

FIG. 3. *Myrmecochilus marshalli* Wasm. ×4. (After Wasmann.)

Other myrmecophilous Cetoniinæ occur both in Europe and in North America. In the former country the larvæ and pupæ of *Cetonia floricola* Herbst are very common in the nests of *Formica rufa* and *pratensis;* and in the United States, as Schwarz has shown, *Euphoria inda* L., *hirtipes* Horn and probably also *E. pilosicollis*

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breed in ant-nests. The larva of *E. inda* is recorded from nests of *Formica integra* and the adult from those of *F. rufa obscuripes*. During the spring of 1906, while watching a large nest of *F. exsectoides*, I saw a *E. inda* fly from a distance, alight on the mound and at once bury itself out of sight in the earth and vegetable débris. *E. hirtipes* has also been taken in the nests of *F. obscuripes* by Brunner. It appears, therefore, that all the myrmecophilous Cetoniinæ have a predilection for ants of the genus *Formica* or of the allied genus *Plagiolepis*, which represents *Formica* in South Africa. That this predilection is exhibited by so many genera of the subfamily and in such widely separated regions as South Africa, Europe and North America, shows that it must be of very ancient origin.

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STUDIES ON MYRMECOPHILES. II. HETÆRIUS.

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The myrmecophilous beetles of the Histerid genus *Hetærius*, which are widely distributed over the north temperate zone, have attracted the attention of a number of entomologists. Lewis (1884) has described a couple of species (*H. gratus* and *optatus*) from the nests of Japanese ants. The common European *H. ferrugineus* has been briefly studied by Ernest André (1874), Escherich (1897), Forel (1874), Gradl (1879), von Hagens (1865, 1879), Janet (1897), Janson (1857), Lucas (1861), Marseul (1853–62), and Wasmann (1886, 1894, 1898), and several North African species have been described by Lewis (1888a, 1888b) and Thery (1897). Some attention has been paid to our North American *Hetærii* by Brues (1903), Cockerell (1890), Fall (1907), Liebeck (1891), Schwarz (1889), and Wickham (1892).

Most of these authors, however, merely record the occurrence of the beetles with certain ants (in several instances inaccurately identified) but tell us nothing about their habits. Indeed, apart from their occurrence with certain hosts, the habits of all the species, except the

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European *H. ferrugineus*, are unknown. We may, therefore, regard this form as the ethological type of the genus. In his "Verzeichniss" (1894), Wasmann has taken great pains to record the names of the host ants with which *ferrugineus* has been found, both by himself and earlier authors. The regular host is unquestionably *Formica fusca*, either alone or when living as an auxiliary, or slave with *F. sanguinea* or *Polyergus rufescens*. Less frequently the beetle occurs in the nests of other European species of *Formica*, several species of *Lasius*, *Tapinoma erraticum*, *Myrmica scabrinodis* and *Leptothorax acervorum*.

Wasmann (1886) gives the following account of the behavior of *ferrugineus* in nests containing *fusca*: "I believe that the ants are quite indifferent to the beetle, as Forel, too, has remarked ("Fourmis de la Suisse," p. 426). According to my observations *Polyergus* pays no attention to it, and *fusca* little or none. The beetle, nevertheless, is continually foisting itself on the ants. It scampers about among them, climbing now on this individual, and over its back, now on that, and anon allowing itself to be carried along passively on some ant's back. It seeks out by preference the densest swarm of ants and climbs from one to another. *Polyergus* seems to be unaware of its existence. This ant neither starts nor moves her feelers or legs but behaves as if the *Hetærius* were not walking over her. Once only I saw a *Polyergus* throw the beetle off, but the latter had run over her clypeus just as she was about to clean her face with the strigil of her fore leg. When a *Polyergus* encounters the beetle she takes no notice of it, and this is usually also the case with *fusca*. Twice, however, I saw a *fusca* touch the beetle's head and thorax with her mouth, but I was unable to determine the nature of the contact as it lasted only a few seconds. It was certainly not accidental. During this encounter the beetle applied its legs to its body and remained motionless, but hurried away as soon as the ant withdrew her mouth. I repeatedly saw a *fusca* take notice of one of the beetles. She approached it slowly, palpated it from a distance with her antennæ and then remained standing for some time without touching it. Apparently she was in doubt about the object and afraid to feel of it again. When a beetle crept about on a *fusca* the latter sometimes (but rarely), moved impatiently, but did nothing more. The beetle feeds on dead and wounded ants. I saw it repeatedly perched on the abdomen of such ants, boring with its head and fore feet into a wound and remaining in this position for some time." Wasmann (1908) made similar observations on a speci-

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men of *H. ferrugineus* placed in a mixed colony of *F. exsecta* and *fusca*. In this case, however, the ants licked the beetle more frequently and effusively.

These and other observations have led Wasmann to regard *H. ferrugineus* when nesting with *F. fusca* as a synœkete, or indifferently tolerated guest. Janet (1897), too, who observed the beetle in artificial nests of the same ant, came to a similar conclusion. He found the beetle mating during July and during June making attempts to escape from the nest.

The following observations, however, prove that in nests of *Lasius alienus* the relations between the beetle and the ants are much closer and more in the nature of symphily. Escherich (1897), who studied these insects in Asia Minor, says: "I kept six of these beetles and a few *Claviger* for eight weeks in an artificial nest and would summarize my observations as follows: The *Hetærii* are true guests or closely allied to the true guests, as Wasmann has already stated. The ants often lick the beetles, their pygidium, wing covers, etc., as I have repeatedly and clearly discerned under a lens. As a second fact in support of this opinion, I may state that *Hetærius* is not infrequently carried about by the ants, an occurrence which has been observed in many true guests (*Claviger*, *Paussus*, etc.). This transportation, which is perhaps best interpreted as a kind of 'play' or 'practice,' indicates that the ants, when attacked, or when moving to a new nest, carry their guests with them, just as they carry their larvæ and pupæ on such occasions. . . . Before leaving *Hetærius*, let me relate a little episode from the life of this Histerid. On uncovering the nest I saw an ant attempting to seize one of the beetles. Time and again she made the attempt, but her mandibles kept slipping from the beetle's polished, chitinous integument. Finally she succeeded in seizing the stranger by the leg and was thus enabled to carry it a short distance, till it suddenly slipped out of her jaws. Thereupon she made no further attempts to seize it with her mandibles, but rolled it along a considerable distance with her fore feet, as if it were a barrel, while it kept its legs closely applied to its body."

Although the typical hosts of *H. ferrugineus* are Camponotine ants of the genus *Formica*, some of the North African species have been found in the nests of Myrmicinæ. *H. plicicollis* Fairmaire lives with *Aphænogaster striola*, according to Bedel (Wasmann, 1894), and *H. chobauti* Thery with *Monomorium salomonis* (Thery, 1897). Other species,

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according to Lewis (1889), live with *Aphænogaster testaceopilosa*, and, according to Lucas (1855), *H. cavisternus* is found in the nests of *Messor barbarus*.

Our American species are nearly always found in the nests of *Formica* species, as shown by the following records:

1. *H. blanchardi* Lec. — Recorded from a nest of *Aphænogaster fulva* by Schwarz (1890).

2. *H. morsus* Lec. — Taken in a nest of *F. fusca* var. (probably *argentata*) at West Cliff, Colorado, by Cockerell (1890).

3. *H. horni* Wickham. — Taken during May by Wickham (1892) in the nest of *F. schaufussi* at Cheyenne, Wyoming.

4. *H. minimus* Fall. — Taken during March at Boulder, Colorado, by Cockerell in a nest of *Lasius niger* var. *americanus*.

5. *H. tristriatus* Horn. — Schwarz (Wasmann, 1894) mentions this species as occurring in nests of *F. fusca* var. *subænescens* in Colorado, and of *F. obscuripes* in the District of Columbia. The latter locality is probably a *lapsus calami* for British Columbia, since *F. obscuripes* does not occur in the Atlantic States and *H. tristriatus* is likewise a western insect. Schwarz (1890) also cites this beetle as occurring with *F. schaufussi* at Helena, Montana. Brues (1903) has figured a specimen taken by Professor H. Heath in a nest of *F. subpolita* at Pacific Grove, California.

6. *H. brunneipennis* Rand. — This beetle appears to be confined to the Eastern States and has been taken only in the nests of our common species of *Formica*. It is cited by Schwarz from nests of *F. fusca* (evidently var. *subsericea*) and I have taken it both with this ant in New York State and with *F. neocinerea* in Illinois (1902). Blanchard and Liebeck (1891) have encountered it in the larger mounds of *F. exsectoides*.

H. brunneipennis is the only one of our American species whose habits have been briefly noticed, and the only account of these which I have seen, is the following note published by Liebeck some years ago: "A recent addition to the collection at the Academy of Natural Sciences of Philadelphia is a hill of the mound-building ant, *Formica exsectoides*, from the vicinity of Altoona, Pa., containing a living colony of ants, measuring about three feet in diameter at the base and about two feet high. It is remarkable, considering the size, that over two hundred examples of *Hetærius brunneipennis* have been captured upon the exterior of the hill, seemingly creating a doubt as to whether

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it is really a colony of ants, or one of *Hetærius*. The first specimens were observed by Mr. W. J. Fox, on March 30, 1891, and since then the writer has taken small lots at intervals of three or four days, covering a period of six weeks, the specimens gradually getting less abundant. The lower half of one side of the mound, which is almost perpendicular, is completely honey-combed by exposed galleries, and out of these occasionally one or two *Hetærius* would suddenly make their appearance and roll to the bottom of the hill. Apparently the ants had carried these to the open ends of the galleries and unceremoniously tumbled them out. A great many times ants were observed emerging from the galleries with *Hetærius* in their jaws, which they would carry a short distance from the mound and drop, the ants returning without giving them any further attention. Nearly all the *Hetærius* that were seen in motion, were intent upon entering the hill, but were usually bottled before they could do so. Sometimes the *Hetærius*, when touched with a wisp of straw, would double up their members and drop, feigning death after the manner of other members of the family. At other times when touched they would display considerable activity, and although awkward and unwieldy in appearance could run along quite rapidly. An examination of small heaps of dead ants in the extreme corners of the table, upon which the mound had been placed, failed to discover the presence of any *Hetærius*."

During the past April I repeatedly found specimens of *H. brunneipennis* in nests of *F. subsericea* near Bronxville, Westchester County, New York, but never in such numbers as reported by Liebeck. In most instances a colony contained only one or two beetles, more rarely from five to a dozen. In many of these colonies there were also numerous specimens of the little Silphid synœkete, *Ptomophagus parasita* Lec. April 12 seven *Hetærii* were placed in an artificial nest with a number of *F. subsericea* workers and larvæ and kept under observation till June 30. The following notes show very clearly that the relations of these beetles to the ants are in several particulars unlike those described by Wasmann, Janet and Escherich for the European *ferrugineus*. Although the golden-yellow trichomes are scattered over the elytra and thorax of *H. brunneipennis* (Fig. 1) and not collected in masses on the sides and front of the thorax, as in some of the species from the Western States (*e. g.*, *H. tristriatus*), these structures nevertheless powerfully attract the ants. The beetles run about the nest with surprising agility, considering the awkward shape of

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their body and legs, or stand motionless with the anterior part of the body elevated and the fore pair of legs raised from the floor, turned forward and strongly flexed at their femorotibial joints. When a beetle in this position happens to be touched by the antennæ of a passing ant, it begins to wave its fore legs as if to attract attention. The ant stops, begins to lick the beetle or seizes it with her jaws. The body of the latter being very hard and smooth slips from her grasp but the ant redoubles her efforts. She either seizes it by one of its legs, since the beetle does not feign death and withdraw its appendages, but allows itself to be carried about the nest, or she stops, seizes it with her fore feet and, holding it in a vertical position, proceeds to lick its head in a very quick and effusive manner. For some time the beetle keeps its head withdrawn into its thorax, after the Histerid fashion, till the ant stops abruptly, protrudes her tongue and regurgitates a drop of food on its face. Then the beetle protrudes its head, opens its mouth, works its jaws and rapidly absorbs the liquid which sometimes floods the whole cavity in the fore part of the thorax. Thereupon the ant again falls to licking the beetle as if to wipe its face free from the moisture and either leaves the creature to its own devices or regurgitates another drop. Again and again the licking and feeding may alternate as if the ant were fascinated with her pet and could not feed and fondle it enough. This performance is, in fact, so frequently repeated that I could nearly always observe it whenever I uncovered the nest. I have rarely witnessed a more comical sight than the behavior of these slender, black ants while they are holding the chunky, little, red urchins in their jaws and pouring liquid into them as if they were so many casks. Comical, too, is the behavior of the beetle while it is waiting to be noticed, with its head and fore legs elevated. At such times it assumes a ridiculous, cocky air and often, instead of receiving the caress and food which it is expecting, it is inadvertently knocked over onto its flat back by

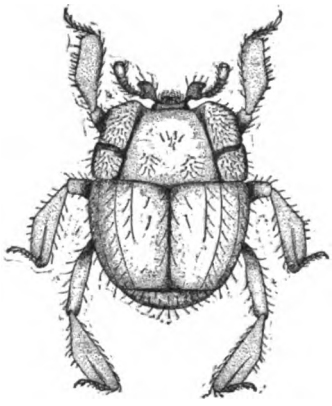

FIG. 1. *Hetærius brunneipennis* Rand. × 16.

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some scurrying ant intent on more important business. Then the beetle lies for a few moments with sprawling legs but soon succeeds in righting itself and either scampers away or at once strikes its favorite attitude again. It seems to be greatly aided in the righting movements by the peculiar position of its tarsi, which are strongly flexed backward on the tibiæ, so that when it is lying on its back, the claws are brought into the most advantageous position for taking hold of the floor of the nest.

Like the European *ferrugineus*, *H. brunneipennis* also feeds on solid substances. It eagerly seeks out any dead or wounded ants on the refuse heap of the nest and may be seen gnawing at their joints or mouth-parts or eating its way into the soft parts of the gaster after having made a large hole in the chitinous investment. It will also spend hours gnawing away with its sharp little mandibles at the bodies of caterpillars and other insects that have been partially eaten by the ants. Occasionally the body of a single small caterpillar or dead ant will be covered with the beetles, all busily feeding. At such times the ants often come up, tear them away and feed them with regurgitated food. The beetles straighten up and patiently submit to the fondling, licking and feeding, but as soon as the ants move away, return to their ghoulish repast.

May 31 I introduced two living *Thecla* caterpillars into the nest and observed them in the act of exuding droplets of liquid from the mouth-like orifice in the mid-dorsal line of their penultinate segment. The ants eagerly imbibed these droplets and, to my surprise, some of the *Hetærii* crawled up onto the backs of the caterpillars, detected the gland and drank the exuding liquid. By the following day one of the caterpillars had pupated and had been deposited on the refuse heap, the other had been killed and reduced to a shriveled skin by the hungry ants. At this skin the beetles were busily gnawing when I uncovered the nest.

The beetles never made any attempts to leave the nest but seemed to be well satisfied with their board and lodgings. May 31 two of them were *in copulâ*, but no eggs nor larvæ were subsequently seen. Towards the latter part of June the beetles died off one by one till June 30, when only a single individual survived. On this date I was compelled to discontinue my observations.

The foregoing notes show that *H. brunneipennis* of the Eastern United States is a true symphile, since, unlike the European *ferrugineus*, it is treated with marked friendliness and is actually fed by its

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hosts. That it nevertheless retains its synœketic habits intact is shown by its feeding on the insect refuse in the nest. These habits are probably very useful in enabling the beetle to live in colonies of indifferent or even hostile hosts. Schwarz and Wasmann have noticed the great development of the trichomes in the *Hetærii* from the Western States and have naturally concluded that these species are in all probability true symphiles. It is, indeed, probable that their relations to their hosts are even more intimate than those of our eastern *brunneipennis* to *F. subsericea*. If this should prove to be the case, the genus *Hetærius* would exhibit an interesting series of ethological stages, beginning with synœketes like the European *ferrugineus* in *fusca* colonies, passing into a sub-symphilic stage in this same species when living with *L. alienus* and exhibiting a more perfect symphily in *H. brunneipennis* and especially in the species of the Western States. Our meager knowledge indicates that the numerous other myrmecophilous Histeridæ that have been recorded by various authors, are mainly, if not exclusively, synœketes or synechthrans, that is, insects living in the nests of ants as indifferently tolerated or as persecuted intruders. These furnish an interesting subject for future observation and comparison.

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STUDIES ON MYRMECOPHILES. III. MICRODON.

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Few insects have occasioned more perplexity in the minds of entomologists than the species of *Microdon*, or, more accurately speaking, than the larvæ and pupæ of *Microdon*, for no tyro in entomology could fail to recognize the imagines as Syrphid flies. So repeatedly have even experienced observers been deceived by the singular elliptical larvæ and puparia, that the history of the genus is unusually instructive. The adult flies have been described under a variety of generic names: *Microdon* (Meigen, 1803), *Aphritis* (Latreille, 1805), *Ceratophya* (Wiedemann, 1830), *Chymophila* (Macquart, 1834), *Dimeraspis* (Newman, 1838), *Mesophila* and *Ubristes* (Walker, 1849 and 1856), and, to add to the confusion, Conrad, in 1842, described a genus of Silurian bivalves under the name of *Microdon*. The larva of the common European species, *M. mutabilis*, was first seen by von Heyden, who in 1823 described and figured, but refrained from naming it. He says that he does not believe it to be "the larva of an insect (perhaps a species of fly) for its whole organizaation, especially the structure of its mouth-parts, is too different from that of any insect larva" known to him. So he concludes that "it is much more probably a mollusk, but if such be the case, it must constitute a new and extraordinary genus." The following year (1824) von Spix found the larva of the same species of *Microdon*, and believing it to be a slug, named it *Scutelligera amerlandia*. Thereupon von Heyden published a second paper on the creature and dubbed it *Parmula cocciformis*, for the joy of naming things was as great in the early decades of the nineteenth century as it is to-day. The name *cocciformis* seems to have suggested to Burmeister (1839) that the creature was the "larva of a *Coccus* living on oaks"; at any rate, he enumerates it among the *Coccidæ*. The same year Schlotthauber presented to the German naturalists assembled at Pyrmont a carefully written paper with illustrations to prove that the organisms described by von Heyden and von Spix as mollusks, were really the larvæ of *Microdon mutabilis*. Unfortunately this paper was never published; a brief reference in Oken's "Isis" of 1840 being apparently the only record of its contents. In 1845 Elditt

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endeavored to make good this loss to science in an excellent article on the metamorphosis of the insect. But the resemblance of the larval *Microdon* to a naked mollusk has contined to breed new generic names down to the present day. Prof. T. D. A. Cockerell calls my attention to a recent article by Simroth (1907), in which he describes what is evidently the puparium of a *Microdon* or of some allied Syrphid genus, from Cape Flats, South Africa, as a new genus and species of slug (*Ceratoconche schultzei*) to be placed "between the genera *Testacella* and *Apera*." Simroth actually interprets the posterior tubercle of the puparium as a vestigial shell! There is apparently no reason why unusual *Microdon* larvæ and pupæ, as fast as they are brought to light in various parts of the world, should not become the types of futile genera of naked mollusks, at least till the millennium arrives, when naturalists no longer itch to attach a name to everything that swims within their ken.

The genus *Microdon* embraces about 70 described species, and seems to be cosmopolitan in its distribution. Many of the species, however, are highly variable and have been but little studied, so that it is impossible at present to give more than a general account of their number, range and habits. According to Schiner (1864) and Verrall (1901), there are only three or four species in Europe. Aldrich (1905) enumerates 28 from North America. Lea (1893) has found the larvæ of a form, which he calls *M. variegatus*, in New South Wales. Simroth, as we have seen, has described the puparium of a South African species, and several have been recorded from South and Central America and Madagascar (Sharp, 1899; Wasmann, 1894).

The larval and pupal stages of these singular insects are found only in the nests of ants, wasps and termites. Wasmann (1890) seems to be the only author who has seen them in wasp nests. In his list of myrmecophiles and termitophiles (1894) he mentions their occurrence also in the termitaria of Madagascar and Brazil. Most frequently, however, both in temperate and tropical regions, the larvæ and puparia are found living with ants. In these stages the insects are gregarious, as a rule, so that several may be seen clinging to the walls of the galleries and chambers. They seem to live indifferently in nests in the soil, under stones, under the bark of trees or in the cavities of branches. The larvæ, while young or partially grown, often inhabit the deeper recesses of the nests, but when they reach maturity and are ready to pupate, they emigrate to the surface

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and are then found near or at the entrances. They creep very slowly, with a wave-like motion of the flat and viscid ventral surface, which so closely resembles the foot of a slug, and keep the fringed border of the body in close contact with the surface over which they are moving. The anterior end, however, is occasionally raised for a few moments. At such times one may see the small pointed head of the larva moving about uneasily under the fringed border as if in search of food. What this food is, has not been determined, Laboulbène (1882) surmised that it might be the ant larvæ, but I am inclined to believe that it is the minute pellets of food, which, after their moisture has been extracted, are ejected from the hypopharyngeal pockets of the worker ants. These pellets are scattered about the nest, especially about the superficial galleries, and though hard and dry, must contain considerable nutriment. They are probably eaten not only by the *Microdon* larvæ but also by many other syncœketes (*Clytra*, *Coscinoptera*, etc.).

The larvæ of the common European and North American *Microdons* are usually of a dirty white or drab color, with yellow or brown fringes of hair-like processes around their creeping sole, and a prominent, heavily chitinized tubercle near the posterior end. Usually no traces of segmentation are to be observed in their elliptical bodies, but in some adult larvæ of *M. tristis*, just before pupation and after their upper surfaces had been dried by exposure to the air, I have been able to discern in certain lights a distinct division of the body into seven or eight subequal segments. When the time for pupation arrives the larva remains stationary on its creeping sole, contracts somewhat, becomes harder and more convex and of a deeper brown color. The reticulations or markings, with which the upper surface is sometimes ornamented, become more pronounced, and a pair of short tubercles or protuberances make their appearance near the anterior end in addition to the single respiratory tubercle at the posterior end.

I am convinced that there is but one annual brood of these insects, at least in temperate regions, and that the larvæ, after passing the winter in the ant-nest, pupate in April or May. The flies hatch early in June and are much less active than other Syrphidæ. They are most frequently taken in sweepings in meadows or rather low grounds. During July young larvæ may be found in the nest and these mature by autumn. I believe, therefore, that Mann (1882) must be mistaken when he claims to have seen several specimens of

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Microdon globosus issuing from a hole in the woodwork of a house and infers that they had been hibernating in this retreat.

The habits of the European *Microdons* have been studied by a number of entomologists: Bertkau (1889), Bignell (1891), Elditt (1845), Gadeau de Kerville (1884), Laboulbène (1882), Mayet (1882), Poujade (1883*a*, 1883*b*), Schenck (1852), Verhoeff (1892), Wasmann (1891, 1894), Wissmann (1848), and others. Of the two common species, *M. mutabilis* L. and *M. devius* L., the former is cited by Wasmann as occurring in the nests of *Formica rufa, fusca* and *rufibarbis*, and of *Lasius niger, brunneus* and *flavus*, the latter in nests of *F. fusca, sanguinea* (with *fusca* slaves) and *L. fuliginosus*.

So far as I am able to ascertain, but one of our numerous North American species, *M. tristis* Loew, has been bred from the puparium. Packard (1869) does, indeed, figure a puparium and fly which he refers to *M. globosus* Fabr., from a specimen taken by Sanborn at Andover, Mass., but I have recently examined the specimen, which is in the Museum of Comparative Zoölogy, and find it to be without doubt a puparium of *tristis*. Lintner (1885) reproduced Packard's figure and description, which he also erroneously attributed to *globosus*. Both the Museum of Comparative Zoölogy and that of the Boston Society of Natural History contain specimens of *tristis* mounted on the same pins with the puparia from which they were reared. During May, 1907, Mr. W. T. Davis reared the flies from a lot of twenty-four *tristis* puparia which I found at Newfoundland, N. J., in a nest of *Formica schaufussi*, and during the spring of 1908 I reared a number from puparia found at Bronxville, N. Y., and Paterson, N. J. In both of these localities the host ant was *schaufussi*. My collection also contains specimens of the adult insects and puparia taken in the following localities and with the following ants: Manchester, N. J., with *Formica* (species undetermined); Colorado Springs, with *F. rufa obscuripes* Forel (July); Colebrook, Conn., with *F. difficilis* var. *consocians* Wheeler (June 30); South Harpswell, Maine, with *F. sanguinea aserva* Forel (July). There are puparia of *tristis* in the Museum of Comparative Zoölogy from Loon Lake, Washington; Binghampton, N. Y., and Boston, Mass. (Henshaw).

In 1906 I published a few notes on some larvæ of *tristis*, one of which lived in an artificial nest of *F. consocians* from July 7 till September 10. On the former date I found three young larvæ in a nest of this ant at Colebrook, Conn., together with some empty

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puparia from which the flies must have escaped during the previous spring. The ants resented my interference by moving to a new nest. On July 25 I found two more partly grown larvæ in the deserted formicary, but these were weak and emaciated. This shows that the *Microdons* do not accompany the ants when they move, and that the presence of the latter is essential to the well-being of the former. The emaciated condition of the abandoned larvæ is easily accounted for, if they feed, as I believe they must, on the ejected hypopharyngeal castings of their hosts.

The larva of *M. tristis* (Fig. 1) is 8–10 mm. long, opaque, pale, dirty brown or dark drab above and lighter beneath. The border is brown and striated and bears a simple fringe of short, flattened and pointed hair like processes. The convex dorsal surface is covered with a coarse reticulum consisting of pale gray, cord-like elevations, which converge toward the anterior end and the posterior tubercle. On closer examination the convex surface is seen to be divided into five subequal areas by four longitudinal strips which are rather free from reticulations. The posterior tubercle is short, robust, rounded, opaque, yellow, and covered with minute papillæ of the same color as the reticulum on the dorsal surface. This tubercle is surmounted by the two reniform anal stigmata, which are sometimes connected by a bridge. They are dark brown and shining.

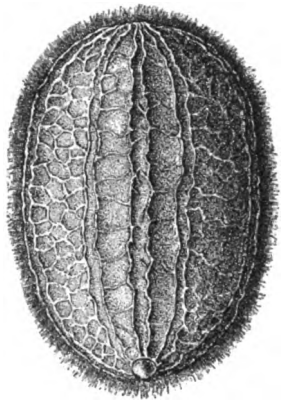

FIG. 1. — Larval *Microdon tristis* Loew; dorsal aspect. ×6.

The puparium is of the same size as the adult larvæ, but more convex and dark brown in color. Its sculpture is like that of the larva, but there are two prothoracic tubercles, each less than twice as long as broad, slightly diverging and somewhat obliquely truncated at their tips, which are shining and covered with minute papillæ.

The following additional observations on *tristis* were made during the past spring. April 19 I found a flourishing colony of *F. schaufussi* under a large flat stone in a sloping pasture at Bronxville, N. Y. The nest contained twelve adult larvæ and twelve puparia of *tristis*, all attached to the smooth earthen walls of the galleries either at their entrances or not more than 3 cm. below the surface of the soil. In

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the flat superficial chambers there were also several of the earthen cases of *Coscinoptera dominicana* containing pupæ. Part of the *schaufussi* colony was confined in a Fielde nest together with the *Microdons* and the *Coscinoptera*. The ants paid no attention to either of these insects. By April 22 all the *Microdon* larvæ had attached themselves to the glass floor of the nest and had pupated. May 15 and 16 ten of them hatched, and eight of them hatched on May 20; the six remaining failed to develop. The flies emerged by breaking off the cover formed by the tripartite anterior third of the dorsal portion of the puparium and were at first of a dull drab color. Their bodies were moist and their covering of pile was glued to the chitinous surface. While in this stage they walked about among the ants without being noticed or, at any rate, without being molested. After a few hours, or sometimes much sooner, their wings had expanded and were folded over each other on their backs, their integument had acquired the adult metallic coloration and the pile had dried and become conspicuous. They remained very quiet except when rudely touched. Then they emitted a loud humming sound, but without moving their wings. This peculiar behavior has also been noticed by Bignell (1891) in *M. mutabilis*. The humming attracted the ants, which at once seized the defenseless creatures by the legs or wings and drenched them with formic acid. This killed them almost instantly. After seven had been dispatched in this manner, I removed the others from the nest in order to save them. These observations show very clearly that the adult *M. tristis* is treated with pronounced animosity even by ants among which for many months it has been tolerated with indifference as a larva and as a pupa. It is probable that the migration of the full-grown larvæ to the entrances of the nest and their pupation in the superficial galleries are an adaptation to making it as easy as possible for the adult flies to escape to the open fields without being noticed by the ants. All of my flies hatched at night and I believe that this must be the time of emergence also out of doors. The nights in May are apt to be cool, so that the ants would be in a torpid condition or huddled together in the lower chambers of the nest, and would not molest the flies while they were expanding their wings and perhaps even mating and ovipositing in the nest. In several instances, as in the case of the *F. consocians* nest mentioned above, I have found empty puparia in nests containing partially grown *Microdon* larvæ. This would indicate that the flies are apt to oviposit in the

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very nests in which they have passed their larval and pupal stages. Verhoeff (1892), however, has seen the adult flies hovering about and apparently attempting to oviposit among the ants on the outside of the nest.

M. tristis, like other members of the genus, is highly variable in size and coloration. To some extent this variability may be geographical, since this species is known to range from the Mackenzie River to Virginia and from Maine to Washington and Oregon. Williston (1886) describes a var. *ruficrus* from Connecticut and regards *M. cothurnatus* Bigot from Oregon as being merely a variety of *tristis*. I have found still another variety which cannot be due to geographical causes, since it was bred from one of the twenty-four puparia taken in the *schaufussi* nest described above. The puparium from which it emerged was indistinguishable from the others, but the adult insect was covered with rich orange-yellow pile, whereas the seventeen other specimens had the pale yellow or silvery pile of the typical *tristis*. I have seen two other specimens of this orange variety in the American Museum of Natural History. Both of these were collected by Mr. W. Beutenmuller, one at Grant's on the Indian River, Fla., the other in sweepings with several specimens of the typical *tristis* and *globosus* in low ground at Katonah, N. Y. (June 4–14). This singular variety suggests a number of questions: Does it indicate that *M. tristis* is dichromatic like certain species of birds? Or is it a mutant? And if a mutant, is it an adaptation to more intimate symbiotic relations with the ants? In other words, does the orange-yellow pile have the same significance as the trichomes of the true myrmecophiles (symphiles), and would its possessor be more amicably treated by the ants than the typical *tristis*? I could, perhaps, have answered this last question, had not my specimen died soon after leaving its puparium.

M. globosus Fabr. and *M. fuscipennis* Macq., two other North American species not uncommon in collections, have not yet been bred from their puparia. I have seen a larva and puparium which are quite unlike the corresponding phases of *tristis* and probably belong to one or the other of these species. The larva measures 8–11 mm. It is opaque, pale brown above and lighter beneath. The dorsal surface is smooth and not covered with reticulations, but in dried and alcoholic specimens may be vermiculately wrinkled from contraction. The border has two fringes of golden yellow hairs, separated by a rather broad space crossed by sparse transverse ridges.

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The more dorsal fringe consists of very delicate, short, curly hairs, while the ventral fringe is borne on a diaphanous striated lamina and is made up of flattened hairs, with long, slender, flexuous tips. The anterior border of the body is distinctly notched in the middle. The posterior tubercle is very long (1.7 mm.), with a ring-like groove around its base, and terminates in a pair of short blunt processes, each of which bears one of the anal stigmata. The whole surface of the tubercle is somewhat shining and finely rugulose.

The puparium measures 11 mm. It is smoother, more convex and somewhat darker brown than the larva. The anterior tubercles seem to be replaced by a pair of large, broadly elliptical discs or spots, representing less heavily chitinized areas of the puparial wall.

Larvæ and puparia of this description were found in a nest of *F. fusca* var. *subsericea* at Fort Lee, N. J., during April. I have some larvæ also from two localities in Massachusetts, collected in nests of the same ant by Mr. A. P. Morse and Mr. A. C. Burrill, and there are in the Museum of Comparative Zoölogy several specimens taken in the same state by Mr. E. A. Samuels.

We may conclude from the foregoing account that the typical and most frequent hosts of *Microdon* in the north temperate zone are the species of *Formica*. In tropical and subtropical regions, however, where this genus of ants is absent, the hosts belong to different and often to very diverse genera. Wasmann (1894) mentions *Camponotus hildebrandti* as the host of a *Microdon* in Madagascar. I have given an account (1901) of the larva of another undetermined species from the nest of *Pseudomyrma mexicana*, one of the fiercest of our American ants, and Brues (1903) has described and figured a very peculiar puparium, which probably belongs to a genus allied to *Microdon* and was taken in California by Prof. H. Heath in the nest of a very small black Myrmicine ant, *Monomorium minutum* Mayr. I find no mention of the species of ants with which the other recorded tropical and subtropical *Microdons* have been taken. We should expect the Australian forms to occur in the nests of *Iridomyrmex* species, the South African forms with the larger species of *Plagiolepis*.

The relations of *Microdon* to its hosts appear in an interesting light if we compare this insect with *Cremastochilus*. The larval and pupal *Microdon* are synœketes and are usually indifferently tolerated. Occasionally, however, the ants attack them even in these stages although they are well protected by their hard skins and marginal

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fringes. The imaginal insects are treated as synechthrans, or persecuted intruders, and are quite defenceless. The larval and probably also the pupal *Cremastochilus* are synechthrans, or at any rate the ants would destroy them if they did not protect themselves by hiding away in the soil. The adult beetle may become indifferently tolerated, though it seems generally to be treated with hostility. Still it is well protected by its hard armor, so that it walks about the nest with impunity like the larval *Microdon*. Thus each of these myrmecophilous genera has its Achilles heel. At first sight this seems to show a lack of adaptation in a portion of the life cycle (larval and pupal stages in *Cremastochilus*, imaginal stage in *Microdon*), but a broader view suggests that what appears as a defect is really an advantage, both to the parasite and its host, for it prevents the former from exceeding a proper numerical relation to the latter. In other words, it is better for *Cremastochilus* and *Microdon* to sacrifice individuals and thus become rather rare forms, than to over-run the colonies and seriously disturb the domestic economy of their hosts.

ADDENDA.

To the account of *Cremastochilus* and *Hetærius* given in the former studies of this series, I would add the following notes:

During the past summer I succeeded in finding the larvæ of *Cremastochilus castaneæ* in a nest of *Formica fusca* var. *glacialis* Wheeler, at South Harpswell, Me., and in rearing the beetles. I have described the larval and pupal stages in a recent paper (The Ants of Casco Bay, Maine, With Observations on Two Races of *Formica sanguinea*, Bull. Amer. Mus. Nat. Hist., XXIV, 1908, pp. 619–645).

In my summary of the records of *Cremastochilus*, I unfortunately omitted an important paper by Wickham (On Coleoptera Found with Ants. Fifth Paper. Psyche IX, 1900, pp. 3–5). This author cites *C. harrisi* as occurring with *Formica pallidefulva nitidiventris* Emery (Lowa, May 4) and *C. saucius* and *knochi* with *Pogonomyrmex occidentalis* Cresson (*opaciceps* Mayr). *C. saucius* was taken by E. J. Oslar at Denver, Berkeley and Salida, Colo. (April 10–July 11), *C. knochi* at Berkeley (April 8) and Chimney Gulch, Colo. (June 18). Oslar is quoted as stating that the former species occurs singly in the *occidentalis* hills at all times of the year, and Wickham adds that "it is difficult to get perfect specimens of this beetle, the legs often being much mutilated supposedly by the ants, which are large and fierce creatures."

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It is probable that the primary, or regular hosts of these two *Cremastochili* are to be found among the many species of *Formica* which abound within the geographical range of *P. occidentalis*, and that this latter ant is merely a secondary, or accidental host. This is indicated by the fact that I have recently received from Mr. W. Knaus a specimen of *C. knochi* taken at Stockton, Utah, by T. Spalding in a colony of a very pale form of *Formica sanguinea subintegra* Emery with *F. subpolita* slaves.

In the same paper Wickham mentions the occurrence of *Hetærius brunneipennis* in the nests of *Formica fusca* var. *subsericea*, in company with *Ptomphagus parasita*.

Wasmann (The Guests of Ants and Termites, Entom. Record, XII, 1900, pp. 204, 205) publishes the following note on the common European species: "Just one word about *Hetærius ferrugineus* and its allies. What seems easier at first sight than that a small Histerid, which already possesses in its oval shape a kind of protection, should force the ants to receive it as a lodger, and which would be tolerated because of its being unattackable, and that finally the ants, taking pleasure in licking it, would elevate it to the rank of a true guest. But it is not as simple as it appears. In my observation-nests I have had a number of *Hetærius* for more than five years, and I have come to the conclusion that it would be better for this species to be merely tolerated. It is in truth licked by the ants, but this is not to its advantage, as the ants do not feed it. It is often in great danger. *Formica sanguinea* and *pratensis* play with it for a quarter of an hour at a time, like a cat plays with a mouse, trying to get hold of its jaws, so it is often hurt. Once a *Hetærius* was so badly used by a *Formica sanguinea* that it was half killed and nearly devoured. Whilst licking the wounded beetle the ant's greed had been awakened."

In a later paper (Zur näheren Kenntnis des echten Gastverhältnisses (Symphilie) bei den Ameisen- und Termitengästen, Biol. Centralbl., XXIII, 1903, p. 207) Wasmann makes a few remarks on the adipose tissue and notices the large size of the ovarian eggs of *H. ferrugineus*. He kept a pair of these beetles for more than three years in an artificial nest, but they never oviposited and he saw neither larvæ nor pupæ.

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